Experimental assessment of the mast shadowing effect on the wind speed sensors
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Abstract
Presently, common practices recommend wind turbine siting to be based on local measurement data, obtained with masts instrumented with an array of sensors for wind regime characterization. As known, this type of experimental apparatus implies some interference in the flow, leading to deviations between sensor’s output and flow properties.

In this context, when using wind data collected by anemometers installed in meteorological masts, it is essential, on one hand, to properly instrument the station, ensuring the mast’s influence on the anemometers is minimal, and, on the other hand, to stay aware of some typical phenomena to ensure that the interpretation of the data is correctly carried out.

The presented methodology studies the wind speed variation along a direction perturbed by the mast using sonic anemometers instrumented in a lattice structure and placed at different distances from the mast. The followed approach tries to quantify phenomena as the blockage effect, the reduction of the wind speed in the wake region and the increase in the turbulent intensity as functions of the distance to the mast, allowing comparison between the IEC standard approach and the experimental results.

Objectives
It is the purpose of this study to contribute for the assessment of the wind field nearby the met masts. Thereby, the first goal to achieve is the influence of the structure on the wind speed measurements, as it is, in general, the most important flow property to consider. The adopted position of the sensors in the mast aims to allow the understanding of the blockage and wake effects on wind speed data. The turbulence intensity is also under appreciation, particularly when the anemometer is on the wake region of the flow. The approach here presented tries to quantify the deviation on these wind characteristics as functions of the distance to the mast.

Methodology

In order to achieve the abovementioned objectives, a met station was instrumented with a cup anemometer and a wind vane, top mounted, and two sonic anemometers boom mounted. The orientation of the sonic anemometers is along the North-South axis where one of the sensors, sonic south, is exposed to free wind when its blowing South and the other, sonic north, is on the perturbed side of the structure. The experiment was composed by three different periods, each one corresponding to a different arrangement of the anemometers. The simplified scheme presented, figure 1, depicts the arrangement used to collect data for second and third periods.

Before these two, the anemometer sonic north was deployed on the top of the mast, next to the cup anemometer, in order to validate it as reference for the following tests. For a better understanding of the experiment note:

- First period, A1 - arrangement one (validation period) – 1465 valid records
  - Cup anemometer - top mounted (fixed)
  - sonic south - oriented south, \( \theta = 1.5 \text{ m} \)
  - sonic north - oriented west, top mounted
- Second period, A2
  - Cup anemometer - top mounted (fixed) – 2385 valid records
  - sonic south - oriented south, \( \theta = 1.5 \text{ m} \)
  - sonic2 north - oriented north, \( \theta = 0.5 \text{ m} \)
- Third period, A3
  - Cup anemometer - top mounted (fixed) – 1121 valid records
  - sonic south - oriented south, \( \theta = 0.5 \text{ m} \)
  - sonic2 north - oriented north, \( \theta = 1.5 \text{ m} \)

For the validation period A1, the wind data from sonic north and cup anemometers was computed and correlated in order to verify if the cup sensor can be user as reference for the incoming arrangements. As can be seen in the figure 2, at right, the correlation is excellent despite some well known differences in what concerns *modus operandi* of both sensors. For this exercise the directions above 180 degrees and below 200 were considered undisturbed – Southerly winds.

During A2, the influence of the tower in the wind speed becomes clear. Figure 3, at left, depicts the difference between the horizontal wind speed recorded by cups and downwind the mast, on top plot, while the plot below shows the that difference computed between north and south sonic anemometers. In what concerns the standard deviation and the turbulence intensity it was observed, as expected, an increasing on the turbulence, in the wake region of the flow. This increasing was computed on 1.5 % for arrangement A2, in which the sonic north is sited 0.5 meters from the tower, considering records from 160 to 200 degrees.

To refer that the results of the analysis turbulence analysis must be prudently regarded. The high turbulence figures observed in urban environment must be taken into account and this 1.5 % increasing value cannot be extrapolated to other environments. Therefore, it is considered that in smooth terrain this difference can be higher than here presented.

In figure 5 the variation of the Delta Vh with the distance to the mast can be seen and it is based on the measured filled points.

Conclusions and Future Work
Considering the results presented above, it is concluded that the influence of the mast in the wind measurements can assume an important rule on the data quality, if the instruments are placed to near the structure. As expected, its influence in the wind speed reaches relatively high figures, about 12 %, while for the turbulence intensity the mast influence was set on 1.5 % at a distance of just 1.5 m from the structure.

If shadowing of the mast is quite visible, the blockage effect is hardly noticeable.

Larger boom lengths may be required in sites where the wind rose is not so well defined and a significant amount of records may be affected.

Given the growth of boom length may imply additional vibration and consequent interferences on measurements, this feature should also be assessed in the future.

References